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New montane records for the Vulnerable Long-nosed Bromeliad Salamander, *Dendrotriton megarhinus* (Rabb, 1960) (Caudata, Plethodontidae), from Cerro La Bola, Chiapas, México

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Abstract. The salamander *Dendrotriton megarhinus* (Rabb, 1960) (Caudata, Plethodontidae*)*, previously known only from Cerro Tres Picos in La Sepultura Biosphere Reserve, Chiapas, Mexico, has been found at Cerro La Bola, Chiapas, extending its geographic range. In this report we provide four new records and outline aspects of the species' ecology as well as threats to its habitat. Despite conservation efforts, the species remains Vulnerable to threats like climate change and infectious disease. We emphasize the importance of its conservation and the continued monitoring of the species and its habitat.

Key words. Cloud-forest amphibians, conservation, Chiapas herpetofauna, distribution, ecology, Sierra Madre of Chiapas

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INTRODUCTION

Neotropical salamanders constitute 40% of the world's salamander species (Rovito et al. 2016). These non-aquatic, lungless amphibians are highly sensitive to environmental conditions and depend on moist habitats. The cloud forests of Central America harbor a remarkable diversity of salamander species. These forests provide essential environmental conditions and refuges from desiccation and extreme temperatures (Wake 1987). However, the distribution of salamanders is closely tied to cloud forests, which are often isolated. Consequently, habitable areas for plethodontids are separated by valleys or lowland areas, which results in discontinuous distributions influenced by past climatic fluctuations (Wake and Lynch 1982). The genus *Dendrotrit on* Wake & Elias, 1983, includes eight species of plethodontid salamander that are allopatrically distributed from southeastern Mexico to northeastern Honduras (Wake 1987; Rovito et al. 2012). Due to historical climate fluctuations, the habitable areas for *Dendrotriton* have been reduced to isolated patches resulting in allopatric distributions and vicariant speciation (Wake and Lynch 1976; Rovito et al. 2012). Only two species of this genus are present in Mexico: Long-nosed Bromeliad Salamander *Dendrotriton megarhinus* (Rabb, 1960) and Xolocalca Bromeliad Salamander *D. xolocalcae* (Taylor, 1941). Both species inhabit small portions of the cloud forests in the Sierra Madre de Chiapas, a mountain chain that runs parallel to the Pacific Coast.

While *D. xolocalcae* is present in at least three locations in the Sierra Madre de Chiapas, *D. megarhinus* is a micro-endemic species that, like the other species of its genus, lives exclusively in bromeliads in montane cloud-forest habitats (Wake 1987). Until now, the only recognized population of *D. megarhinus* was recorded in the core zone of La Sepultura Biosphere Reserve in a remote area on Cerro Tres Picos mountain in southern Chiapas, Mexico, at 2100–2425 m a.s.l. (IUCN SSC Amphibian Specialist Group 2020). The species is currently considered Vulnerable according to the IUCN Red List, and under special protection by Mexican Regulations (SEMARNAT 2010). This is because of its limited geographical distribution, its small population size, and its vulnerability to the effects of climate change and infectious diseases, like chytridiomycosis (IUCN SSC Amphibian Specialist Group 2020).

We report here the presence of *D. megarhinus* outside of its previously known geographic range.

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METHODS

From October 2020 to June 2021, we conducted seven field visits to the Sierra Madre in Chiapas, Mexico. In February of 2021, we recorded the presence of *Dendrotriton megarhinus* in a locality at the core zone of Cerro La Bola in La Sepultura Biosphere Reserve (REBISE, Figure 1) through visual encounter surveys carried out from 10:00 h to 16:00 h (Crump and Scott 1994) and active searches through bromeliads in a cloud forest at an elevation between 1700 and 1900 m a.s.l. The specimens were collected with permission obtained from the Secretaría de Medio Ambiente y Recursos Naturales, SEMARNAT (SGPA/DGVS/02965/21). The specimens were photographed on site and were then euthanized by immersion in a solution of 2% lidocaine for 10 min. The specimens were preserved in 10% formaldehyde and stored in 70% alcohol at the Colección Herpetológica at El Colegio de la Frontera Sur (**ECO-SCH**) where individuals were measured. To compare the morphology of these specimens, measurements of 17 morphometric traits were taken from four specimens obtained from Cerro La Bola and five individuals from Cerro Tres Picos previously deposited in ECO-SCH (Bingham et al. 2018). The following measurements were taken using digital calipers to record the body dimensions of each specimen: snout–vent length (SVL), tail length (TL), axila groin distance (AG), Chest width (CHW), Forelimb length (FL), hindlimb width (HL), hand width (HW), foot width (FW), snout–gular fold distance (SG), head width (HeadW), eye diameter (ED), (Int) internarial distance, orbitonarial distance (OD), eye–snout distance (ES), interorbital distance (Iorb), intercantal distance (Ican), nostril length (NL). Symmetrical characters were taken from the right side of the specimens. Subsequently, we conducted a principal component analysis (PCA) to assess morphometric traits in both populations and to reduce dimensionality by retaining the most informative variables. This also allowed us to identify any evidence of separation or grouping among individuals. Prior to performing the analysis, we applied a correction to the morphometric data using the Thorpe (1975) formula to avoid potential allometric bias in individuals body size. Specifically, we calculated the adjusted value for each morphometric character as follows:

$$X_{adj} = \log(X) - b[\log(BL) - \log(BL_{mean})]$$

Where X_{adj} = Adjusted value for character X; X = raw/unadjusted value for character X; b = denotes the regression coefficient (slope) obtained from regressing log(X) against log (BL); BL = measurement of body length/size; BL_{mean} = grand mean of BL. This method scales all individuals to the same size and adjusts their shape to the new size avoiding allometric effects. Data were evaluated using the GroupStruct package (Chan and Grismer 2021). PCA analysis was performed with the FactoMiner v. 2.4 package (Lê et al. 2008) in R. Finally, we plotted the variables with the highest contribution to the first two components. We excluded tail length measurement from the analysis because the tail was missing in four individuals. Additionally, we calculated and mapped the species' area of habitat (Figure 1), based on the range of elevation and the prediction of cloud forest ecosystems in the region, obtained using the raster layer provided by Wilson and Jetz (2016), which shows the relative occurrence rate of tropical montane cloud-forest cover at a global scale.

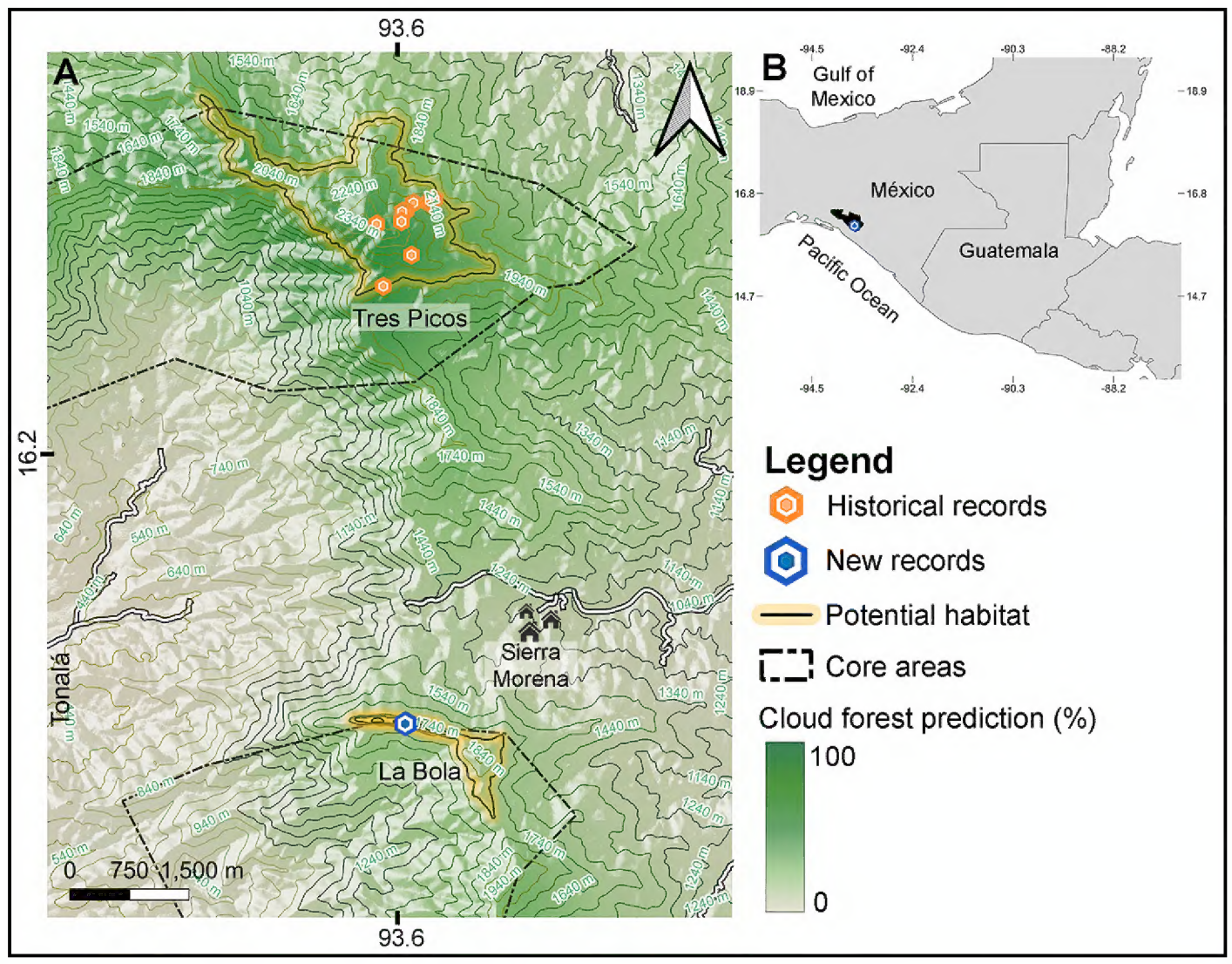

Figure 1. Distribution of *Dendrotriton megarhinus*. **A.** Map showing historic and new records from Cerro La Bola, along with the area of its potential habitat based on field observations and by relative occurrence rate of tropical montane cloud forests, presented as percentage. **B.** Macrolocation of REBISE in Chiapas, Mexico.

RESULTS

Dendrotriton megarhinus (Rabb, 1960)

New records. MEXICO – CHIAPAS • Villa Corzo municipality, Sierra Morena, Reserva de la Biosfera La Sepultura, Cerro La Bola; 16.1388°N, 093.6090°W; 1780 m a.s.l.; 23.II.2021, 16:05h; R. Bolom-Huet leg.; caught by hand, inside a bromeliad, genus *Tillandsia* L.; 1 ♀, ECO-SCH-4941 • Same locality; 16.1388°N, 093.6091°W; 1780 m a.s.l.; 25.II.2021, 11:50h; L. Caloca-Peña leg. inside a bromeliad, genus *Werauhia* J.R. Grant; 1 ♂, ECO-SCH-4942 • Same data as above; 1 ♀, ECO-SCH-4943 • Same data as above; 1785 m a.s.l.; 25.II.2021, 12:15h; R. Bolom-Huet leg.; 1 ♀, ECO-SCH-4944.

We recorded the presence of four individuals of *D. megarhinus*. These individuals were found in a locality not previously described 6 km south of Cerro Tres Picos (Figure 1) and 2.5 km from Sierra Morena, Villa Corzo Municipality, Chiapas, Mexico. The catalog numbers and morphological measures of collected specimens are shown in Table 1. The species' habitat occurs in the montane cloud forests of REBISE, and covers an area of 650 m² at an elevation above 1780 m a.s.l. The climate is tropical sub-humid with a rainy season in the summer and a dry season in the winter. Total annual precipitation is between 2000 and 3000 mm. Temperatures oscillate from 15 to 20 °C in the upper zones and slopes of the mountains. This vegetation remains perennial throughout the year, even during the dry season, due to fog, and this favors the presence of epiphytes. The specimens were observed inside bromeliads, 2 m above the ground. In at least one bromeliad, two salamander specimens were observed together (ECO-SCH- 4942 and 4943). Additionally, we observed that *D. megarhinus* shares a habitat with the hylid frogs *Plectrohyla matudai* Hartweg, 1941 and *Ptychohyla euthysanota* (Kellog, 1928), the plethodontid salamanders *Bolitoglossa franklini* (Schmidt, 1936) and *B. occidentalis* Taylor, 1941, and the endemic lizard *Abronia morenica* Clause, Luna-Reyes & Nieto-Montes De Oca, 2020.

Identification. The specimens were determined to be *D. megarhinus* based on their morphological traits (Table 1) and by considering the ecological characteristics of the genus. These salamanders have arboreal habits and relatively typical external morphology with slender, medium-sized bodies and a tail longer than the rest of their body (Figure 2A; Rabb 1960; Wake and Elias 1983; Wake 1987). *Dendrotriton megarhinus*

Table 1. Measurements of the external morphological characters (in mm) of the four specimens collected in Cerro La Bola and five specimens from Tres Picos locality; the catalog numbers of the Colección Herpetológica ECOSUR are displayed. SVL = snout–vent length, TL = tail length, AG = axila groin distance, CHW = Chest width, FL = Forelimb length, HL = hindlimb width, HW = hand width, FW = foot width, SG = snout–gular fold distance, HeadW = head width, ED = eye diameter, Int = internarial distance, OD = orbitonarial distance, ES = eye to snout distance, Iorb = interorbital distance, Ican = intercantal distance, NL = nostril length, NA = Not applicable.

	Tres picos					La Bola			
Characters	**ECO-SCH 0673** ♂	**ECO-SCH 0674** ♀	**ECO-SCH 0675** ♀	**ECO-SCH 0676** ♀	**ECO-SCH 0677** ♂	**ECO-SCH 4941** ♀	**ECO-SCH 4942** ♂	**ECO-SCH 4943** ♀	**ECO-SCH 4944** ♀
SVL	20.6	14.8	15.1	15	15.3	15.7	15.9	17.2	15.5
TL	20.1	NA	NA	NA	NA	8.3	18.1	13.6	20.6
AG	9.5	7.3	8.1	8.4	7.8	8.6	8.9	9.2	8.4
CHW	2.7	1.9	2.3	2.1	1.9	2.4	2.0	2.2	2.4
FL	5.3	4.5	4.1	3.8	4.1	3.5	4.1	4.2	4.8
HL	5.9	4.3	4.6	4.7	4.6	3.4	4.3	5.1	5.1
HW	1.5	0.9	1.1	1.2	0.9	1.1	0.8	0.9	1.1
FW	2.2	1.3	1.3	1.3	1.4	1.1	1.0	1.2	1.1
SG	5.2	3.4	3.7	4.2	3.9	3.8	4.4	4.4	4.6
HeadW	3.8	2.8	2.9	2.9	2.8	2.8	2.9	3.1	3.1
ED	1.8	1.4	1.3	1.4	1.4	1.2	1.2	1.2	1.4
Int	0.8	0.8	0.8	0.8	0.9	0.6	0.7	0.5	0.8
OD	0.7	0.6	0.6	0.5	0.8	0.5	0.6	0.3	0.5
ES	1.5	1.6	1.3	1.2	1.6	1.5	1.4	1.7	1.4
Iorb	2.0	1.2	1.2	1.2	1.7	1.1	1.2	1.1	1.2
Ican	1.4	1.2	1.5	1.5	1.5	1.2	0.9	1.6	1.1
NL	0.9	1.1	0.9	0.9	1	1.01	1.0	0.9	0.9

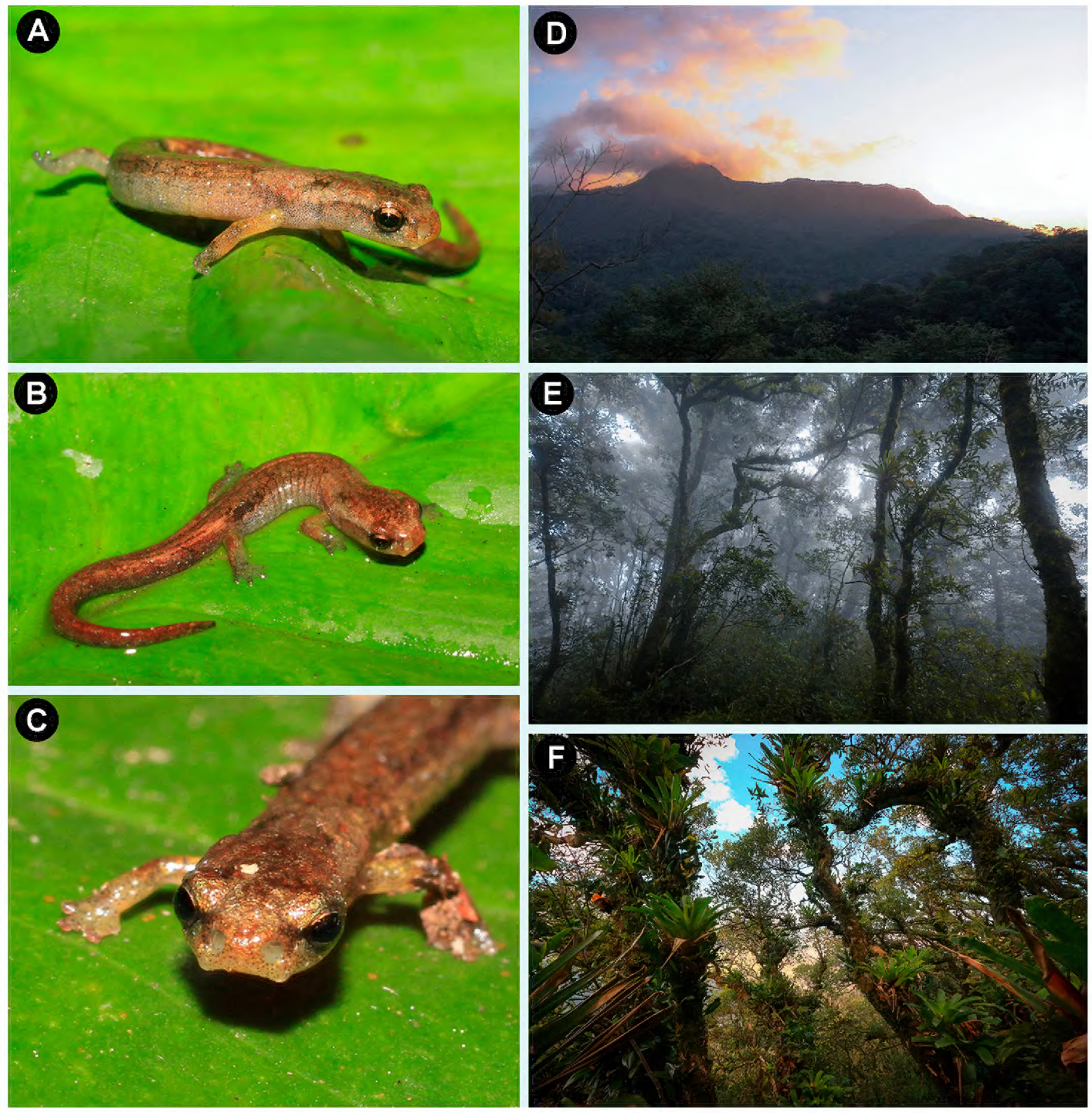

Figure 2. *Dendrotriton megarhinus* and its habitat. **A, B.** ECO-SCH-4944, adult specimen observed at Cerro La Bola, REBISE. **C.** ECO-SCH-4941, an individual from the front where the large nostrils characteristic of the species is evident. **D.** View of Cerro La Bola from Sierra Morena. **E, F.** Detail of the montane forest, the habitat of the newly recorded species.

can be distinguished from congeners by its large nostrils that protrude into an elongated snout (Table 1, Figure 2). It differs from *D. xolocalcae*, the other *Dendrotriton* species occurring in Mexico, by its significantly larger nostrils, longer snout, shorter limbs, and longer tail. Additionally, *D. xolocalcae* has a compact body and is smaller in size compared to *D. megarhinus* (Lynch and Wake 1975). The large nostrils were observed in four individuals collected at the newly recorded site (Figure 2A–C). These individuals also had long extremities and digits that were slightly webbed by an interdigital membrane (Table 1). This species varies in color from dark brown to red and occasionally has dorsolateral stripes (Figure 2B, C) or dark, triangular spots on the head (Rabb 1960). The PCA of morphometric characters resulted in two principal components (Figure 3A): PC1 retained 53.9% of the variation, while PC2 retained 20.9% of the explained variation. A separation between the individuals of both localities is shown, being more pronounced in the first principal component (PC1), while the 95% confidence interval indicates overlap (Figure 3A). The variables with the highest contribution (%) to PC1 were OD = 32.3, Int = 16.9, FW = 16.7 and IORB = 16.4 (Figure 3B) while for PC2 were: HW = 35.4, Ican = 20.3, Orb = 16.5, CHW = 7.5 and ES = 6.9 (Figure 3C).

DISCUSSION

The records of *Dendrotriton megarhinus* at Cerro La Bola widen the previously known distribution and elevation range of the species at Cerro Tres Picos, they also broaden the elevational range for all *Dendrotriton* species. Currently, only *D. bromeliacius* (Schmidt, 1936) has been recorded below 2000 m a.s.l. (IUCN SSC Amphibian Specialist Group, 2020). Until now, there was no evidence of the presence of *D. megarhinus* outside the core area of Cerro Tres Picos. The description of this species by Rabb (1960) indicates that the paratypes were collected from the north slope of Cerro Tres Picos. Since then, studies on the genus have only included specimens from that locality (Lynch and Wake 1975; Collins-Rainboth and Buth 1990; Wilkinson 1997; Rovito et al. 2012).

Previous studies on *Dendrotriton* of have enabled the morphological distinction of species in the genus (Lynch and Wake 1975). Our morphometric analysis reveals that the individuals of *D. megarhinus* exhibit morphological differences between the localities, particularly in head measurements. However, this result should be interpreted with caution due to the small sample size and the expected variability indicated by

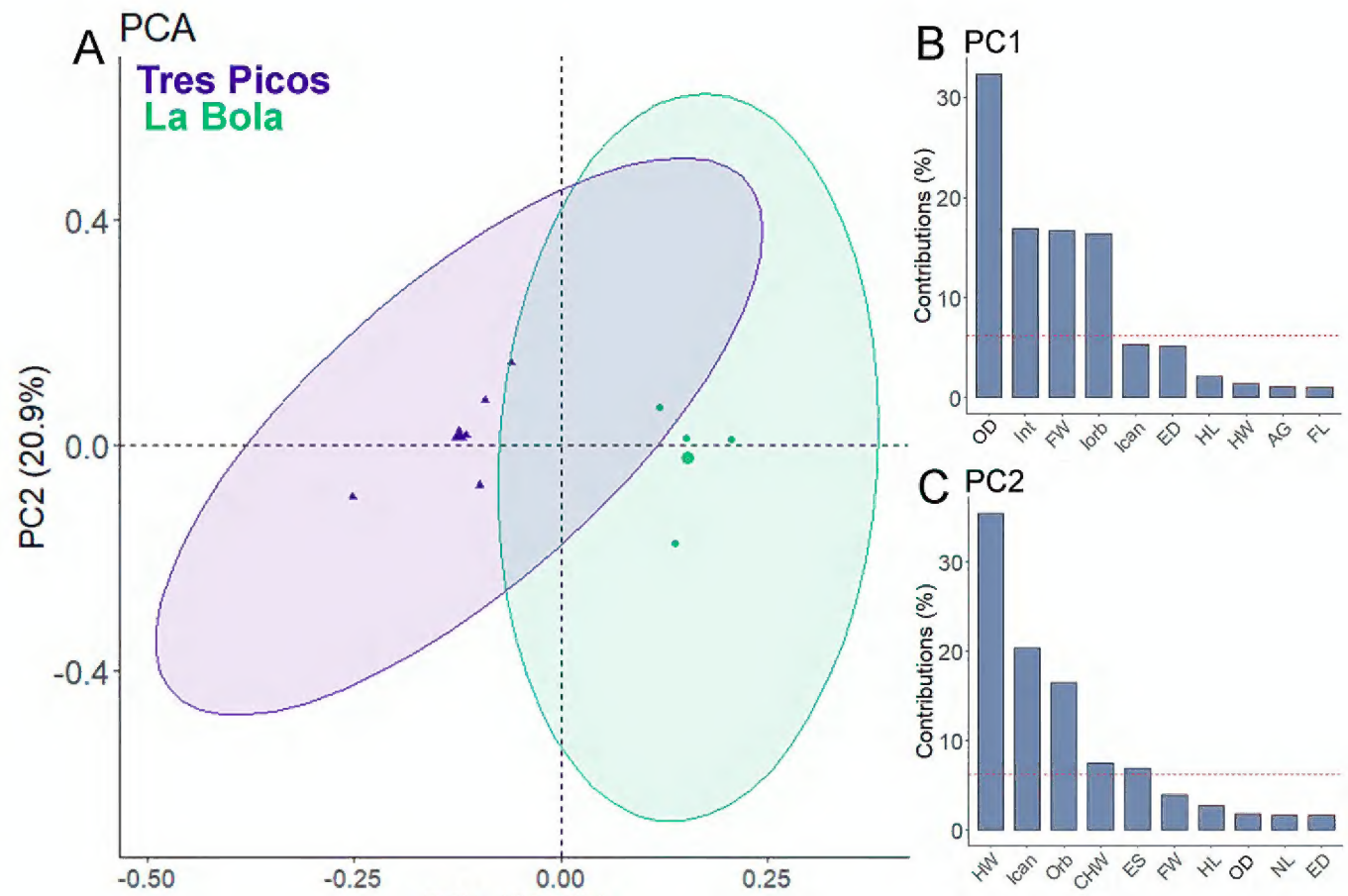

Figure 3. PCA plot. **A.** Biplot of individuals analyzed; confidence ellipses = 95%. **B.** Contribution of the variables analyzed for PC1. **C.** Contribution of variables analyzed for PC2. Red lines indicate the expected average contribution.

the confidence ellipses (Figure 3), which show a marginal overlap between localities. Additionally, the size of the nostrils was remarkable in the specimens examined, a feature not observed in other *Dendrotriton* species (Rabb 1960).

The distribution of *D. megarhinus* is a consequence of the highly specialized nature of the species, the region's intricate geography, a history of fluctuations in climate, and the effect of vicariance on species with limited distribution ranges (Rovito et al. 2012). Its habitat is found in the zone with the least ecological connectivity of the Sierra Madre de Chiapas (Bolom-Huet et al. 2022) due to the complex topography and an abrupt drop in elevation in the direction of the Isthmus of Tehuantepec (Wake and Lynch 1976). Considering the range of elevation at the site in Cerro La Bola and the presence of cloud forests (Karger et al. 2021), the habitat of *D. megarhinus* in this new locality is calculated to be an area of less than 1 km (Figure 1).

Cloud forest is the most threatened ecosystem in Mexico due to its small extent (Ponce-Reyes et al. 2012), as it is typically restricted by elevation on mountain slopes (Foster 2001). In REBISE where the cloud forests only occur in three core zones (Cerro La Bola, Cerro Tres Picos, and Cerro Chompipe, CONANP 2013), the suitable habitat for *D. megarhinus* is limited to elevations above 1750 m a.s.l. Despite measures implemented to protect these ecosystems in the region, expected threats to cloud forests are from climate change and extreme weather (Ponce-Reyes et al. 2012; Karger et al. 2021), which makes the species occupying this habitat, including *D. megarhinus*, extremely vulnerable to extinction. In contrast to Cerro Tres Picos, where the cloud forest is in a remote area with minimal human interference (IUCN SSC Amphibian Specialist Group 2020), the habitat of *D. megarhinus* at Cerro La Bola is bordered to the north by a buffer zone and the agricultural fields of Sierra Morena, where coffee and palms are cultivated by local farmers. These two locations are separated by a depression characterized by semi-evergreen tropical forest, secondary vegetation patches, and agricultural fields (INEGI 2016). Moreover, due to the region's high scenic value and accessibility, local communities have developed low-impact ecotourism, which has led to a moderate increase in visitors. Among other vulnerabilities identified, the species may also be sensitive to pathogens introduced through human intervention and to the effects of chytridiomycosis caused by the fungus *Batrachochytrium dendrobatidis* Longcore, Pessier & Nichols, 1999, which comes in through the temporary and permanent streams from Sierra Morena where its principal hosts are the hylid frogs *P. matudai* and *P. euthysanota*; both species show a tolerance to the infection and frequently migrate through temporary streams from the lowlands to the cloud forests in search of a humid refuge during dry season (Bolom-Huet et al. 2023).

This study increases our knowledge on the distribution of *D. megarhinus*, along with its possible conservation threats. Current records are relevant to extend the elevational range of *Dendrotriton*, since only two species have been recorded below 2000 m a.s.l. Further field research can provide valuable information about the distribution of range extensions, particularly for these locally endemic plethodontids. This emphasizes the importance of the continued evaluation on the species' ecology as well as conservation efforts to protect these populations from susceptibility to changes in climatic conditions and the effects of emerging infectious diseases.

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ADDITIONAL INFORMATION

Conflict of interest
The authors declare that no competing interests exist.

Ethical statement
No ethical statement is reported.

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Author contributions
Conceptualization: RBH, AS, LCP. Data curation: AMA, LCP. Formal analysis: RBH. Investigation: RBH, AMA, LCP. Methodology: RBH. Project administration: AS. Supervision: AS. Writing – original draft: RBH, LCP. Writing – review and editing: RBH, AS.

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Data availability
All data that support the findings of this study are available in the main text.

REFERENCES

Bingham RE, Papenfuss TJ, Lindstrand L, Wake DB (2018) Phylogeography and species boundaries in the *Hydromantes shastae* complex, with description of two new species (Amphibia; Caudata; Plethodontidae). Bulletin of the Museum of Comparative Zoology 161: 403–427. https://doi.org/10.3099/mcz42.1

Bolom-Huet R, Pacheco XP, Muñoz-Alonso A, Sunny A (2022) Potential distribution and connectivity for two plethodontid salamanders: conservation areas and landscape corridors for two endemic species of México and Guatemala. Environmental Management 70: 965–977. https://doi.org/10.1007/s00267-022-01700-0

Bolom-Huet R, Pineda E, Andrade-Torres A, Díaz-Fleischer F, Muñoz-Alonso A, Galindo-González J (2023) Chytrid prevalence and infection intensity in treefrogs from three environments with different degrees of conservation in Mexico. Biotropica 55: 318–328. https://doi.org/10.1111/btp.13186

Chan KO, Grismer LL (2021) A standardized and statistically defensible framework for quantitative morphological analyses in taxonomic studies. Zootaxa 5023: 293–300. https://doi.org/10.11646/zootaxa.5124.4.4

Collins-Rainboth A, Buth DG (1990) A reevaluation of the systematic relationships among species of the genus *Dendrotriton* (Caudata: Plethodontidae). Copeia 1990: 955–960. https://doi.org/10.2307/1446478

CONANP (Comisión Nacional de Áreas Naturales Protegidas) (2013) Modificación del programa de manejo de la reserva de la biosfera La Sepultura. CONANP, Mexico, 184 pp. https://iefectividad.conanp.gob.mx/i-efectividad/FSIyPS/RB%20La%20Sepultura/Usos%20y%20Ben/Prod%20Sust/PM%20RB%20Sepultura%202013.pdf. Accessed on: 2024-01-05.

Crump ML, Scott NJ (1994) Visual encounter survey. In: Heyer WR, Donnelly MA, McDiarmid RW, Hayek LC, Foster MS (Eds.) Measuring and monitoring biological diversity, standard methods for amphibians. Smithsonian Institution Press, Washington DC, USA, 84–92.

Foster P (2001) The potential negative impacts of global climate change on tropical montane cloud forests. Earth-Science Reviews 55: 73–106. https://doi.org/10.1016/S0012-8252(01)00056-3

INEGI (Instituto Nacional de Estadística, Geografía e Informática) (2016) Conjunto de datos vectoriales de uso del suelo y vegetación escala 1:250000, Serie VI (Capa Unión). INEGI, Mexico. https://www.inegi.org.mx/app/biblioteca/ficha.html?upc=889463173359. Accessed on: 2023-11-15.

IUCN SSC Amphibian Specialist Group (2020) *Dendrotriton megarhinus*. The IUCN Red List of Threatened Species 2020: e.T59239A53979358. https://doi.org/10.2305/iucn.uk.2020-2.rlts.t59239a53979358.en. Accessed on: 2024-01-09.

Karger DN, Kessler M, Lehnert M, Jetz W (2021) Limited protection and ongoing loss of tropical cloud forest biodiversity and ecosystems worldwide. Nature Ecology & Evolution 5: 854–862. https://doi.org/10.1038/s41559-021-01450-y

Lê S, Josse J, Husson F (2008). FactoMineR: An R Package for Multivariate Analysis. Journal of Statistical Software 25: 1–18. https://doi.org/10.18637/jss.v025.i01

Lynch JF, Wake DB (1975) Systematics of the *Chiropterotriton bromeliacia* group (Amphibia: Caudata), with description of two new species from Guatemala. Contributions in Science 265: 1–45.

Ponce-Reyes R, Reynoso-Rosales VH, Watson JEM, VanDerWal J, Fuller RA, Pressey RL, Possingham HP (2012) Vulnerability of cloud forest reserves in Mexico to climate change. Nature Climate Change 2: 448–452. https://doi.org/10.1038/nclimate1453

Rabb GB (1960) A new salamander of the genus *Chiropterotriton* from Chiapas, Mexico, with notes on related species. Copeia 1960: 304–311. https://doi.org/10.2307/1439757

Rovito SM, Parra-Olea G (2016) Neotropical plethodontid biogeography: insights from molecular phylogenetics. Copeia 104: 222–232.

Rovito SM, Wake DB, Papenfuss TJ, Parra-Olea G, Muñoz-Alonso A, Vásquez-Almazán CR (2012) Species formation and geographical range evolution in a genus of Central American cloud forest salamanders (*Dendrotriton*). Journal of Biogeography 39: 1251–1265. https://doi.org/10.1111/j.1365-2699.2012.02696.x

SEMARNAT (2010) Norma Oficial Mexicana NOM-059-SEMARNAT-2010, Protección ambiental—Especies nativas de México de flora y fauna silvestres—Categorías de riesgo y especificaciones para su inclusión, exclusión o cambio—lista de especies en riesgo. Diario Oficial de la Federación 30 diciembre, 2010. https://dof.gob.mx/nota_detalle_popup.php?codigo=517309. Accessed on: 2023-11-09.

Taylor EH (1941) New amphibia from the Hobart M. Smith Mexican collections. The University of Kansas Science Bulletin 27: 141–167.

Thorpe RS (1976) Biometric analysis of geographic variation and racial affinities. Biological Reviews 51: 407–452.

Wake DB (1987) Adaptive radiation of salamanders in Middle American cloud forests. Annals of the Missouri Botanical Garden 74: 242–264.

Wake DB, Elias P (1983) New genera and a new species of Central American salamanders, with a review of the tropical genera (Amphibia, Caudata, Plethodontidae). Contributions in Science 345: 1–19.

Wake DB, Lynch JF (1976) The distribution, ecology, and evolutionary history of plethodontid salamanders in tropical America. Natural History Museum of Los Angeles County Science Bulletin 25: 1–65.

Wake DB, Lynch JF (1982) Evolutionary relationships among Central American salamanders of the *Bolitoglossa franklini* group, with a description of a new species from Guatemala. Herpetologica 38: 257–272.

Wilkinson M (1997) On phylogenetic relationships within *Dendrotriton* (Amphibia: Caudata: Plethodontidae): is there sufficient evidence? Herpetological Journal 7: 55–65.

Wilson AM, Jetz W (2016) Remotely sensed high-resolution global cloud dynamics for predicting ecosystem and biodiversity distributions. PLoS Biology 14: e1002415. https://doi.org/10.1371/journal.pbio.1002415